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ABSTRACT

This paper abstracts and discusses the approaches of five educational theorists who have used quantum theory as a model for educational phenomena, sets forth and uses metatheoretical criteria to evaluate the work of these theorists, and states guidelines for further work in this domain. The paper abstracts and discusses the works of the following educational theorists: D. B. Center (1997), A. Martin-Smith (1995), R. Collier (1974), R. Garmston and B. Wellman (1995), and Schuck and N. Haggerson (1991). It is divided into the following parts: "Introduction"; "Metatheoretical Considerations"; "Educational Theory from Quantum Theory" ("Effective Interventions in Behavior Disorders," "Transforming the Child's Awareness through Drama," "More Effective Foreign Language Teaching," "A Reevaluation of Educational Research Methodology," "A Model for School Adaptability"); and "Guidelines and Questions." Contains 57 references. (BT)

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The impact of quantum theoretical models of consciousness on the study of education

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Presented as a poster session at
Consciousness and its Place in Nature:
Toward a Science of Consciousness

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James Andris

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Introduction

This paper has grown out of the author's nearly lifetime fascination with the subjects of education, consciousness, and reality. For two decades now, I have been reading popular treatises on the implications of quantum theory for macro-level events. (Capra, 1976; Hebert, 1985; Talbot, 1986; Wolf, 1981) More recently, I have read a number of books offering quantum theoretic models for the nature of consciousness. (Cairnes-Smith, 1996; Penrose, 1994; Walker, 1970, 2000) More recently still, I have done a thorough search in ERIC for quantum theoretic models of education, particularly quantum theoretic models of consciousness. To my surprise, I found several documents that met these criteria. In this paper, it is my intention to abstract and discuss the approaches of five educational theorists who have used quantum theory as a model for educational phenomena, to set forth and use metatheoretical criteria to evaluate the work of these theorists, and to state guidelines for further work in this domain.

While other theorists have discussed relationships between quantum theory and educational phenomena, I found the following articles to be specifically focused on this issue. Collier (1974) uses an analogy between quantum theory and meditative states to explore changing levels of consciousness as a help to foreign language learning. Martin-Smith (1995) sees aspects of drama work in children as the metaphoric equivalent of quantum leaps, and sees quantum theoretical perspectives as facilitating a transformational self-concept for the child. Schuck and Haggerson (1991) are inspired by the built-in uncertainty of quantum theory to describe two modes of inquiry for educational research (mythological and evolutionary) as correctives to an over-emphasis on rational inquiry, which emphasizes certainty. Garmston and Wellman (1995) trace the implications for school adaptivity and professional development of the complementarity of content and process and the existence of five types of energy fields in schools, drawing parallels between quantum theory and other newer scientific models. One article directly addresses quantum mechanical models of consciousness as a basis for educational theorizing. Center (1997) sees the theories of Penrose, Cairnes-Smith and others as supportive of 1) a needing to move towards scientific realism, 2) expanding the concept of causation in behavior to include consciousness as a potential causal agent, and 3) emphasizing cooperative, rather than teacher-centered approaches in the conceptual frameworks of behavior-change efforts.

Metatheoretical considerations

Readers who wish to review the specific theories of the five articles mentioned above may skip to the next section. However, at least two general methodological issues need to be addressed in understanding articles such as these. The first issue arises from the fact that in most of these articles certain types of arguments by analogy are being used to develop models of educational phenomena. Attention to the soundness of such arguments will help us understand their validity. The second issue arises from claims that the uniqueness of educational phenomena as human social phenomena either places limits on our knowledge of them or requires that we study them in some special way not required of some other natural sciences.

Three aspects of scientific reasoning

Over thirty years ago, while I was Elizabeth Steiner Maccia's doctoral student at Indiana University, she wrote an important paper titled "Retroduction: a Way of Inquiring through Models." Apparently, this paper was never formally published, but the central thrust of Maccia's (no date) inquiry forms one important basis for my observations in this paper. By polishing Charles Pierce's concept of retroduction as an important component to scientific inquiry, she explicates a third logical process of scientific inquiry in addition to deduction and induction. Maccia's thinking is also clearly influenced by the work of May Brodbeck (1959).

> Through retroduction, one devises characterizations—statements or theory about objects. Through deduction one clarifies and completes such characterizations. Finally, through induction, one determines the objects falling within the range of

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> the characterization. Retroduction devises, deduction explicates, and induction evaluates. (p. 5)

Maccia explicates retroduction by drawing a distinction between being a model of and being a model for. All theories are models of objects, because the statements of which they consist are characterizations of objects. 'Theory' and 'representational model' are synonymous. However, some theories are also models for other theories. Drawing on the example of Maxwell's use of fluid dynamics as a model for the flow of electricity, Maccia explicates this sense of a theory being a model for another theory:

> The theory of mechanics furnished substance (concepts) and form o. structure (ways of relating concepts) that were represented in another system of statements. So the theory of electricity emerged. The theory of mechanics was a devising model for the theory of electricity. Yet it was not the case that the theory of electricity was equivalent to a part or all of the theory of mechanics. There was a partial similarity in substance (isosubstantism) and in form (isomorphism), nevertheless the theory of electricity contained more than the substance and form from the theory of mechanics that were represented in it. This may be generalized as follows: Theory characterizing other objects might furnish concepts or ways of relating concepts or both which can be utilized to characterize the objects we are pondering. If it does, it is a model for devising theory. One theory serves as a point of view from which to set forth another theory. (p. 10)

To further solidify this distinction, Maccia proposes to designate theories that are models of objects as first-order theories, and theories that are models for other theories as second-order theories. Maccia even formalizes her concept of devising model: "A theory X is a devising model for a theory Y when

1) Y contains substance or form or both, Z, from X,
2) Whatever is true of Z is true of Y, but
3) Not whatever is true of Y is true of X." (p. 10)

As we examine the educational literature on quantum theoretic models of consciousness, we will find Maccia's distinctions to be quite helpful in preparing the ground for further such inquiry into education.

One of the authors whose work is being reviewed in the current paper (Collier, 1974) makes some metatheoretical observations about the use of analogy in scientific theorizing. He notes "historically, some analogies have failed, such as that between the structure of an atom and the solar system. Other analogies have led to discoveries of similarities even deeper than were expected; for example, the wave nature of the electron was suggested by analogy to the wave nature of the photon" (p. 152). He apparently is proposing that quantum theory will reveal a deeper understanding of both subatomic particles, macro quantum phenomena such as lasers and super cooled liquids, and consciousness itself.

Collier's insightful comment suggests a generalization of Maccia's formalization of a devising model.

1) Y (a wave theory for electrons) contains substance or form or both, Z (wave properties), from X (wave theory of photons)
2) There is a theory W (wave theory of subatomic particles) such that whatever is true of Z is true of W.
3) Whatever is true of W is true of both X and Y.
4) Not whatever is true of X is true of Y and not whatever is true of Y is true of X.

Just as in Maccia's earlier formulation of a devising model, the truth of any of these theories must be established through induction, which evaluates. The mere proposing of plausible scientific theory which subsumes other theory does not in itself establish the truth of that theory, no matter how initially convincing the analogies or parallels involved seem to be.

Three aspects of observing conscious behavior

This brings us to a second set of rather complex methodological issues associated with this string of writings. Since our topics are quantum theory, consciousness, and educational phenomena, the question arises if there are any unique considerations within any of these domains which require special approaches to verifying the theories in question, i.e. using the process of induction. I can think of at least three such "special" considerations: 1) the implications of the Uncertainty Principle or other unique quantum theoretic principles, 2) the fact that education requires the holding of certain mental states, such as belief and intention, and 3) the use of language (and with it, meaning) to reveal the contents of consciousness, including intention. Some of these considerations have been commented on in the educational literature, others have not.

Unpredictability and uncertainty in human behavior

One should not go very far in explicating these methodological issues without careful study of Gary Cziko's (1989, 1993a, 1993b) work. He presents five arguments for the unpredictability and indeterminacy of complex human behavior of the type of interest to educational researchers (1989). Burge (1990) discussed the significance of Cziko's ideas for distance education. While Cizko's entire paper is fascinating, discussion will be restricted to just those points relevant to the focus in this paper. Two of Cziko's arguments for unpredictability are that, unlike atoms, human individuals differ from one another and that it is plausible that the laws governing these individuals may themselves change. He moves beyond Cronbach and Snow's "*etic*," or quantitative, framework:

> A more qualitative, ethnographic ("emic") approach to the problem of understanding human behavior would consider that it is not the environment or external stimuli described in "objective," etic terms that influences our behavior but rather it is the *meaning* that each individual attaches to his or her experiences of the environment ... [which] is a function of the totality of all previous experiences, something to which the researcher cannot possibly have access."

Cziko begins the line of three arguments that assume an indeterministic perspective by building on Popper (1979) and Bateson's (1979) arguments for an evolutionary view of learning:

> An evolutionary perspective on education that sees learning and development as processes similar to those of biological evolution and the mammalian immune response suggests that we cannot develop theory that would allow us to predict or deduce the educational outcomes of particular educational experiences. Rather, we can at best develop educational theory that is *compatible* with the educational outcomes observed. This perspective sees educational research as primarily a descriptive science that, even if successful in interpreting and explaining, can never provide a basis for the prediction of an individual's behavior or for the prescription of teaching practices. (p. 20)

Cziko's fourth set of arguments hinge upon reflections on the nature consciousness and on examples of consciousness. Again, he reconsiders Popper's (1979) account of consciousness as a higher system which evolved during biological evolution and which, while produced by physical states, controls them to a considerable extent. How consciousness controls events is a function of knowledge of those events. Hence the dissemination of any new knowledge predicting behavior may invalidate those predictions. Cziko also reconsiders a similar argument by MacKay (1967) asserts that the fact that a prediction cannot be made that will hold independently of whether or not it is believed by someone constitutes a "logical indeterminacy" about the future states of people's brains, and hence allows for free will.

Fifth, Cziko discusses the relevance of four properties of quantum mechanics for educational research. He notes in passing three additional aspects of quantum mechanics: "(a) that the simple observation (measurement) of a particle changes the particle, (b) that an entity can exist in

two apparently contradictory states simultaneously ... and (c) Bell's Theorem, which states that all reality is nonlocal ...." (p. 23).

He treats in more in detail the idea of quantum randomness, the essence of which is "identical physical situations (at the quantum level) give rise to different outcomes. He concludes:

> Though presently we can only speculate about the role of quantum randomness in cognitive processes, it is known that quantum phenomena play an important role in biological evolution. ... It would seem to be no great conceptual leap to suppose that similar random events could have similar observable influences on the learning and behavior of human beings. (pp. 22-23)

In a later paper, Cziko (1993a) makes a specific disavowal of this last statement. At this point (1993) he has discovered Perceptual Control Theory (PCT)—of which more later. He says that his earlier (1989) argument does not stand. Rather,

> There are good reasons to expect the behavior of living organisms to be in certain respects *more* predictable that that of inanimate objects. Unfortunately, the traditional "scientific" method of educational research, which looks for relationships between "independent" and "dependent" variables over groups of individuals, may well be incapable of discovering these predictable aspects of human behavior. (p. 13)

At the conclusion of his 1989 paper, Cziko proposes adopting a perspective that "attempts "only" to describe, appreciate, interpret, and explain the social and individual behaviors as well as the cognitive processes relevant to understanding educational phenomena"(23). At the macro level, detailed descriptive studies of all forms of education have value in leading to an appreciation of the possibilities and complexities of education, and providing ideas for fruitful educational innovations. "At the micro level, descriptive studies could be conducted to improve understanding of the social and cognitive development and problem-solving processes of individual students, teachers, administrators, and policy makers" (p. 23).

To illustrate his metatheory, he quotes Stake's (1978) opinion that "one of the more effective means of adding to understanding for all readers will be by approximating through the words and illustrations of our reports, the natural experience acquired in ordinary personal involvement" (p. 5). Stake also contrasts the proliferative nature of case study research with the reductionist character of orthodox educational research. Cziko also cites Gruber's (1985) comment that "probably the most general reason for studying the case is the need to make models of complex processes. Averaging across subjects blurs our view of exactly that which we want to study" (p. 170).

Implications of quantum theoretic principles for verification

As we saw in the previous section, Cziko noted four quantum mechanical characteristics that might have implications for education, and later disavowed any implications of quantum uncertainty for the study of education.

Schuck and Haggerson (1991) not only note implications of subatomic uncertainty and wave/particle duality for educational research, they go so far as to broadly sketch two alternative research paradigms to the familiar traditional, rational approach using the analogy of studying a stream. An abstract of their paper is given below. Garmston and Wellman (1995) note the usual quantum theoretic properties of subatomic particles, but their reflection on the wave nature of matter leads them to postulate a theory (described later in this paper) of individual states of mind that create or are a part of energy fields in organizations.

Other authors who are more focused on the relationship between quantum theory and psychology—notably Wolf (1984) and Mindell (2000)—give fantastic and sometimes highly provocative accounts of this topic. However, fascinating as their writing is, I find them to make great leaps in many places that my mind can simply not follow. Their work notwithstanding, the relationship between quantum uncertainty and macro level uncertainty must remain a plausible

but unproven speculation. The single methodological principle that seems to emerge from all these considerations, baldly stated, is this one: Social scientists, and in particular, educational theorists should stop using a mechanistic matrix as a backdrop for their theories, and open their minds to models of education that share some or all of the properties of subatomic particles. That is, it should be an empirical question, rather than a point in a metaphysical position, whether or not qualities such as nonlocality, superposition, and unmeasurability are manifested by macro level educational and other social phenomena. However, we must remember that the "speculations" of quantum wave mechanics predict the behavior of subatomic particles to many decimal places. Such predictions in macro level behavior have never been demonstrated. The precise relationship between quantum uncertainty and uncertainty in the realm of social phenomena appears to have remained unexplicated.

The reader will note that quantum theory has been used as a devising model for educational theory in several of the studies reviewed here. Table 1 offers a taxonomy of quantum theoretic principles and their relationship to generated educational theory.

Table 1: Taxonomy of quantum theoretic principles and their relationship to generated educational theory

Quantum theoretic property	Notes methodological significance of	Uses to devise educational theory
Coherence: particles share properties with whole (laser, superconductivity)		Center, Collier, Martin-Smith
Complementarity: matter has aspects of both waves and particles		Garmston & Wellman, Martin-Smith
Nonlocality: distant particles connected in space/time at superluminal speeds	Cziko	Garmston & Wellman, Collier, Martin-Smith
Superposition: object occupies two states at the same time	Cziko	Collier, Martin-Smith(?)
Quantum leap: particle transmutes instantaneously from one state to another		Martin-Smith
Quantum leap: particle emits another particle when changing state		Martin-Smith
Quantum leap: particles go into hyperspace between states		Martin-Smith
Quantum uncertainty: identical states can produce different outcomes	Cziko, Schuck & Haggarson	
Unmeasurability: cannot measure a particle without altering its properties	Cziko	Garmston & Wellman,

The science of volitional action

Cziko (1993a) reviews the work of Powers (1973) and an earlier work of McClelland (1994) to present a "new perspective on human behavior" which draws an analogy between the cruise control on an automobile and human goal-seeking behavior. Cziko notes four characteristics of such a system. 1) it does not sense the actual disturbances for which it must compensate and yet maintains goals effectively, 2) it controls what it senses, rather than what it does (hence, in the case of human behavior, the name "perceptual control theory," 3) its behavior is a function of

what it senses compared with its internal goal or reference level, and 4) it is a closed loop, i.e. what it senses affects its response, and its response affects what it senses. Hence, neither can serve as independent variable. What controls the behavior is the internal reference.

The subtext for Cziko's presentation of PCT is that Lehrer, et. al., (1990) had presented strong criticisms of Cziko's earlier (1989) paper. We cannot summarize Lehrer, et. al.'s criticisms here, but Cziko's critique of their arguments is very telling:

> Lehrer et. al.'s model appears to be a one-way external-causation model of behavior that (a) ignores the influence of behavior on perception, (b) provides no explanation for purposeful behavior, and (c) attempts to discover principles of individual human behavior based on statistical treatments of group data. ... [S]uch an approach ... cannot be expected to tell us anything about the psychology or principles of behavior of any individual teacher or student. (p. 17)

The author has not been able to complete a review of the PCT literature. Nevertheless, the works of George Howard will serve to illustrate its usefulness in addressing methodological issues in the study of human behavior. Several papers by Howard and others (1986, 1989, 1991, 1993) appear to contain the essential elements of his work, especially the 1989 paper. He offers a reconceptualization of the free will/determinism issue: human behavior is the result of both agentic (self-caused) and nonagentic mechanisms. Howard's research program has been to enunciate and test a method for showing that self-determination accounts for a large part of the variance in human (purposeful) behavior in certain controlled experimental situations.

Howard and colleagues conducted an extensive series of experiments. Subjects agree to cooperate with the experimenter, who divides the total time for the experiment into a large number of equal-length time blocks. The experimenter assigns each of the time blocks to either "try to --" or "try not to --" conditions (e.g., between-meal snacks, peanut consumption, heterosocial interaction, social alcohol consumption, bingeing behavior) The subject's ability to volitionally control snacking behavior is reflected by differences in the mean number of accomplished acts on "try to" versus "try not to" days. (Howard and Myers, 1989, p. 339) Howard and colleagues found (using partial Eta squared) that more than half of the effect size was due to the volitional element, and in some situations, approached accounting for nearly all of the total variance. External variables, such as written reminders, correlated at a much lower level.

Moreover, Howard and Myers (1989) present a detailed and sophisticated analysis of other possible interpretations of the data. A recurring criticism of this work was that an alternative interpretation is that the subjects were compelled to obey the experimenter's instructions. (Hayes, 1987) A series of experiments was conducted to control variables related to this possibility, e.g. subjects flipped a coin to determine the type of day (try or try not), subjects chose whether they would "follow instructions" or "do the opposite," and experimenter is unaware of what subject condition is operating. The results in these cases remained stable. In one experiment, Howard (possibly with tongue in cheek) performed such an experiment on himself, collapsing the distinction between experimenter and subject. He still exhibited "enormous volitional control."

In one ingenious experiment on the volitional control of alcohol consumption (Howard, Curtin, & Johnson, 1988), subjects converted a significant message (FREE WILL), via Morse Code, into target numbers. (For example, a 2-drink target for a given day represented a "dash" in Morse Code.) The subjects' volition was measured by how close they came to spelling "FREE WILL." However, half the subjects knew they were spelling "FREE WILL," the other half only knew the target numbers. Subjects who knew what they were spelling in their volitional choices showed greater control over their behavior.

It seems to me that the principal value of Howard's work is that he has explicated—in a way that might possibly satisfy those with a traditional quantitative research background—how purposeful behavior can be conceptualized in such a way that its

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efficacy as a causal agent can be demonstrated through experiment. Of course, many of us have an intuitive belief in the causal efficacy of our own chosen behavior. In fact, many of us follow, in an informal way, the exact same within-subject method of equalization that Howard explicates. We make a decision to do something and then we observe whether we are able to bring about the desired outcome. If external conditions are stable enough and if we are effective choosers, frequently the desired outcome does occur. It is the results of the repetition of such attempted choices over time that constitutes the evidential basis for our beliefs about our own causal efficacy, and by analogy, the causal efficacy of others.

It is probably worth noting that in the field of law (and ethics), the entire system is based on a belief in the causal efficacy of purposes. The distinctions of first-degree murder, second-degree murder, or manslaughter would make no sense if a reasonable determination of a person's intention could not be made. Second-degree murder requires pre-knowledge of the possibility of death (as in killing in a rage), and first-degree murder requires a calm intention to kill (premeditation).

Belief, intention, language and meaning in educational phenomena

Cziko and Howard's work has shed light on the question raised earlier, i.e. whether the facts 2) that education requires the holding of certain mental states, such as belief and intention, and 3) that language is used in education to reveal the contents of consciousness, including intention have any unique methodological characteristics. Both of these writers emphasize two aspects of educational phenomena. First, individual humans are unique in a way that individual atoms are not, and hence, we must try to find regularities within individual humans, regularities that may or may not obtain across a group of humans. 2) Howard, in particular, shows us clearly how we might isolate individual human volitional variables. However, he is quick to point out that his methodology is more analogous to the regularities discovered by Mendel in inherited individual characteristics than it is to Watson and Crick's unraveling of the mechanism whereby genetic traits are transmitted. (Cziko, 1989)

I would not denigrate the study of external variables through the use of empirical statistical methods in education, especially as it provides data for informed decision-making. However, the research directions proposed by Cziko and Howard makes more sense to me. Most of what we do in education is to inculcate various values, beliefs, intentions, skills and dreams in individuals. We do this so that the individuals in question may take an informed role in the creation of shared human events, and that the desirability of these events may be facilitated. We live in an illusion of shared human events, namely, our perceptual, holographic construct that we call our experience. Objects in that construct have meaning, as does language, which is a subset of the objects of perception. Spoken and written language have come to be a principal instrument of education, augmenting, of course, the original educational tool, namely, meaningful guidance.

Research that attends to the language and meaningful guidance of education is an essential component of educational research, as is research that attends to the probabilities of educational events as determined by environmental factors. Both are needed for a complete understanding of education. This fact has extreme utility for the understanding and direction of classroom process. Granting that incidental learning accounts for a substantial share of what is learned, it is the intentional learning environment that we strive to set in the classroom. Much of the research that teachers do is on the widely varying states of mind of *individual* students. Teachers and students build and refine theories of each other's intentions, beliefs, values and goals. Clearly, an ideal classroom situation is one in which both the teacher's word and the students' word is their bond, i.e. an ideal climate is one where, by and large, teachers and students can trust each other's statements of intention, including the intention to foster truth. The realities that teachers and students face, of course, are seldom ideal, but occasionally, they are an approximation of the ideal. Research that attends to the probabilities of educational events, in my opinion, is useful to educators only insofar as it can help us to better foster the ideal classroom climate. We need to focus at least as much on research that attends to the language and meaningful guidance of education. Such a focus leads us into typically, but not exclusively, philosophical and humanistic

methods of inquiry. Even science education, if it is methodologically self-conscious, has a philosophic component.

It is beyond the scope of this paper to explicate the philosophic and humanistic methods that will help us to understand the meaning underlying most classroom discourse.[1] The volitional studies begun by Howard and others have just begun to scratch the surface of *meaning*, taken as a phenomenon of study. The study of how it is that language has meaning is yet another layer on top of perceptual control theory. If consciousness is a quantum coherence phenomenon, as several have proposed, the Watson and Crick of the "mechanism" of that phenomenon have not yet communicated with us. But let us now turn to five examples of the use of quantum theory in educational theorizing (and one example of such a quantum theoretic model of consciousness).

Educational theory from quantum theory

Effective interventions in behavior disorders

David Center (1997) has presented us with a balanced overview of contemporary quantum theoretic models for human consciousness, as well as a discussion of some of the philosophical and metatheoretical issues that surround such a study. He then draws out three implications of accepting a quantum theoretic model of human consciousness for the study of human behavior. He notes McClelland's (1994) four basic approaches that behavior change strategies are based upon, and argues against the use of force, threat and incentive and for the use of persuasion as better suited "for facilitating a relatively permanent change in behavior" (p. 15). He then identifies "a number of existing approaches that have possibilities for persuasion-based interventions to facilitate self-directed change in behavior disordered students" (p. 16).

Center contrasts radical behaviorists like Skinner with cognitivists. Both are rooted in a classical mechanistic approach to the study of behavior, but cognitivists see consciousness as playing an important role in behavior. The author amasses arguments and evidence from several inquirers to show that consciousness has a number of qualities that will not yield to an analysis of itself as algorithmic or software-like. More specifically, consciousness exhibits understanding (Penrose, 1994), feeling (Cairns-Smith, 1996), an interaction of understanding and feeling (Damasio, 1994), and unity and complexity (Marshall,1989). Searle (1992) argues that thought is a natural process, which, while it may be simulated by non-natural processes, it cannot be duplicated by them. Therefore, "the search for a physical basis for consciousness must look for a biological process that can produce a macro-quantum effect" (p. 5).

Cairnes-Smith (1996) proposés criteria for evaluating quantum based theories of consciousness: it is a physical effect, it must be accessed through evolution, it must evolve into a distinct structure or process that serves a new function, and it must be somewhat independent of its generating structures. He cites Marshall's (1989) theory as coming the closest to meeting these criteria. Marshall proposes that consciousness is a Frohlich-style Bose-Einstein condensate, i.e. a large number of in-phase photons generated from cell membranes of living tissue (presumably nerve tissue) by metabolic energy, which photons become a whole, sharing and integrating all of their individual properties. Others have generated similar theories. Cairnes-Smith also argues for consciousness as the most recently evolved of three control systems in human beings, one which bears an analogy to serial or sequential processing, which has problem-solving as one of its prime responsibilities, and which has volition and intent as necessary components.

According to Center, the first implication of accepting the theory that consciousness is a natural brain process based on quantum theoretic processes is the need to accept scientific realism, which is a middle ground between positivism and radical constructivism. Since quantum physics

[1] For example, see the work of Ference Marton and Shirley Booth (1997) for a presentation of both the method and the results of phenomenography. This is a highly significant field of study for educational research.

contains entities that are not reducible to physical effects, the new study of consciousness cannot be reductive in the classical mechanical sense.

The second implication of a quantum theoretic model for consciousness, specifically, accepting consciousness as an executive control system, is accepting "a system that employs goals and priorities to organize input and guide decision-making" (p. 12). This rules out theories of behavior that exclude the possibility of individuals being causal agents in their own behavior. He cites both Bandura's (1989) social cognitive theory and the control theory model of McClellan (1994) and Powers (1973, 1980) as being consistent with this second implication. In these theories, "consciousness ... is a dynamic system in which problem-solving strategies may be created, new uses for aspects of the environment discovered and goals modified to reflect a change in the intentions of the organism." (p. 14)

The third implication that Center develops is that viewing consciousness as an executive control system with volition and intent as important components leads us to think differently about selecting strategies for behavioral change. Considering McClelland's four types of such strategies, using force and threat may be faster, but ethical and logistical considerations weigh against them. Incentive is a powerful motivator, but usually requires the continued application of external manipulation to remain effective. Persuasion may be slower and weaker than the other three strategies, but it does not ignore the individual's existing goals. A well-developed persuasive strategy will "convince a student to engage in a cooperative alliance. Persuasion should focus on rationales for changes in goals, priorities or behaviors...[and] on the importance of his or her choices" (p. 16). Center cites a number of existing approaches that have possibilities for persuasion-based interventions to facilitate self-directed change in behavior disordered students, including Perceptual Control Theory, Adlerian psychology, narrative psychology and rational-emotive psychology.

Finally, Center briefly discusses circumstances under which a persuasive approach may not be advisable, principally, medical health problems that are diseases or immediately presenting problems that are a threat to the welfare of the client or others.

I find Center's discussion of the implications of quantum theory for selecting strategies for behavioral change to broadly sketch out an important domain of educational inquiry. However, a definition of persuasion needs to be agreed upon, and a careful review and study of the effectiveness of persuasive methods in securing needed behavioral change needs to be made. Actually, McClelland (1994) uses the word 'influence' instead of 'persuasion' and gives a clear definition of it: "A influences B by acting to create a disturbance from which B constructs a reference level for perceptual control of B's own actions." He gives an extensive explanation of the strengths and weaknesses of influence as a form of behavior control along the lines that Center describes. McClelland is concerned to enunciate a theory of power as a group phenomenon, specifically, social power is constituted by the alignment of reference standards in its individual members. Center's thesis can then be more clearly defined as a counselor/teacher's attempting to directly influence a behavior disorder child to adopt a set of more appropriate reference standards, but not by using force, coercion or incentive. In other words, the counselor communicates or models the reference standards, and the child consciously aligns with these standards because he or she comprehends in some way the appropriateness of this change.

Since I have suggested using McClelland's original term, 'influence,' the second topic to discuss is a careful review and study of the effectiveness of influence as a method in securing needed behavioral change. To take just one example of such a careful inquiry, consider the work of Thomas Krieshok (1998) in reviewing 50 years of empirical literature on career decision making and enunciating a view that "most processing by the human mind for decision making and behavior initiation is not performed at a conscious level and that reflection on those processes may be futile, and detrimental to good decisions." It can be granted that career decision-making is far removed from the exigencies faced by a behavior-disordered child in the classroom. However, if study after study calls into question the role of consciousness in a certain very common kind of decision-making, how much more in question is the role of consciousness in the decision-making of behavior disordered children?

There is one feature of Krieshok's article that places Center's insights in an important perspective. Krieshok states that as theorists have moved from offering prescriptive "rational" models for decision making to descriptive models for decision making (empirically tested), they have found that it looks less and less like a rational process and more and more like an intuitive process with reasons tacked on because of external demand. Apparently, there really is a large amount of empirically verified research proposing such models of career decision making. It would seem that a similar approach would be profitable for research in behavior disorder intervention. Thus for Center's perspective the important questions become: Under what conditions can a counselor communicate or model reference standards for a behavior disordered child? Under what conditions does a child comprehend such model or reference standards? and Under what conditions does a child comprehend the appropriateness of such a change? None of this undercuts Center's important third insight noted above. It merely cautions that conscious behavior may be the tip of an iceberg of mentally guided behavior, especially in the situations of which he speaks.

Transforming the child's awareness through drama

In the article "Quantum drama: transforming consciousness through narrative and roleplay," Alistair Martin-Smith argues "that the leap from self-image to role-image, and from fictional world to virtual world, are the metaphoric equivalents to the quantum leap an excited electron makes when it moves from one orbit to another around the nucleus of an atom" (p. 34). It might be more accurate to say that he uses quantum theoretic concepts and theories of the nature of drama to develop a pedagogical model for transforming a child's consciousness. This theory is quite provocative and leading, but must be regarded as a theory largely untested by any rigorous scientific methodology. This is because quantum theory has been verified for subatomic particles, but not for macro-level events such as changes in a child's role-image.

Martin-Smith is striving to give an adequate description of educational uses of drama strategies. Many educators encourage children to take roles in a drama. These roles are more than just the child's interpretation of a dramatic role, because while in these roles, children enter into dialog with each other. Dialoging in a dramatic simulation, especially when facilitated properly by a teacher, can pull the child out of its own self-image and into a somewhat independent role-image. These experiences are pregnant with meaning, and seem to tap deeper levels of understanding and learning for both teachers and children.

He uses quantum theoretic concepts as model for educational theorizing in several ways, drawing on the work of many authors in the process. 1) Just as an electron which returns to a lower level of energy sometimes releases a photon, educators can often see a new light in a child's eyes immediately after that child returns from role-image to self-image in a dramatic situation. 2) Just as quanta can be seen, but waves are invisible, though the child can be seen, often times his or her learning moments are invisible to the teacher. 3) Just as these electron quantum leaps are discontinuous, so may the child's leap between one role and another be discontinuous. 4) Just as an electron may go into hyperspace when leaping between energy levels, so may children appear to connect with the Jungian collective unconscious during dramatic role-play, accessing archetypical images that guide their enactment of role-image. 5) People project a reality outwards from their brains and nervous systems possibly in the form of a hologram, which is a manifestation of the quantum properties of light. Dramatic role-play with children is the equivalent of a star trek holodeck, allowing the externalization of a virtual reality embodied by the hologram. 6) Just as quantum connections are non-local, so children's drama work may instantaneously transport them from a current to a past space-time location.

Martin-Smith also describes qualities of experience during drama work with children such as "draining away of time and physicality," "myth tapped and universals perceived." and "resonating with personal meaning, beyond time and space." He emphasizes that in a dramatic context, the role that a child adopts is not just a subjective interpretation, but rather subject to the story net cast over the situation and to the dialogic process, with the suggestion that meaning resides therein.

The author develops the idea that children's drama work can transform their consciousness through several arguments. He never actually mentions the property of superposition that characterizes subatomic particles—a property that does not currently exist in macro level mechanics. Nevertheless, the idea that a child can actually entertain two contradictory roles through drama stands out strongly in his writing. He sees the child's exploring contradictions in self as an essential part of self-knowledge. He attempts to give a quantum theoretic basis to his theory of role-play as transformation by alluding to a hypothesis of Wolf's (1984) "concerning the quantum mechanics of learning and memory, based on the creation and destruction of quantum-physical correlations" (p. 39). However, neither Martin-Smith's brief paraphrase nor Wolf's exegesis in Starwave is very clear in setting forth this model, in my opinion. Perhaps his clearest statement is that "activity becomes conscious when our internal holograms—patterns of energy in the brain—are created and destroyed" (p. 41).

Martin-Smith cautions that transforming a child's consciousness will not occur automatically with drama work. The key is the reflective realization by children that they *are* playing roles, presumably in drama work and in life itself. He cautions against "too much passive self-reflection."

Clearly the author has a unique model of a child's reality that he is attempting to communicate. He has used many of the qualities ascribed to subatomic particles, such as wave/particle duality, non-locality, and quantum leap to describe a way of viewing a child's experience:

> Teachers and researchers can begin *to conceive of the active child as a wave motion rather than as a particle.* This means sharing the child's journey through fictional and virtual worlds, following as best we can while he or she is transported beyond linear time and local space. ... When we engage in a mutual dialog with the child, we not only assist the child to meet developmental challenges, but also facilitate the child's developmental process by reflecting the child's changing self-image back to the child. If a child's self-image can be developed and externalized through roleplay, narrative, and other art forms, teachers may be in a unique position to do invaluable practical research by applying the metaphor of the quantum leap to the classroom. (Martin-Smith, p. 42)

I think that Martin-Smith has made a valuable contribution to the education literature here, but I would circumscribe the nature of that contribution carefully. As noted above, Maccia has elaborated on Pierce's concept of retroduction to describe a procedure for developing educational theory through the use of more well-developed scientific models as devising models for less well-understood educational phenomena. The author is careful to underline that he is using quantum theory as a metaphor for understanding drama work with children. It is therefore important not to see his work as an inappropriate and unconfirmable application of quantum theory to macro-level educational events. The question rather appears to be how and in what sense we might measure, describe and understand educational events using analogous educational concepts he defines.

For example, while I am highly skeptical that a measure will ever be developed to measure the number and energy level of the "photons of light dancing in the eyes of the children whom we have guided on imaginative journeys towards self-discovery," it is not at all implausible to me that we might not give a more precise operational meaning to children's expressions which *seem* to dance with light. In fact, teachers might even be trained to recognize and agree that such an event has occurred. Certainly, the author's statement "Quantum theory makes us aware that we can participate in the creation of our own realities, choosing and sharing our own ways of being" (p. 42), points to one value of the theory he has proposed—as an important corrective to a view of education that doesn't give proper credence to the role of a child's choice in the development of his or her personality. The fact that so many clear analogies are found between quantum theoretic properties of subatomic particles and qualities of a child's consciousness in dramatic role-play could be seen as a kind of practical confirmation of more formal scientific efforts to develop a quantum theoretic model of human consciousness. Hopefully, others will find ways to extend and test these several hypotheses about the nature of the development of a child's self-image without attempting to reduce the theory of drama work in children to the quantum theory of

subatomic particles, in other words, to develop and extend a scientific model of an educational process.

More effective foreign language teaching

Roy W. Collier (1974), in an informal way, is attempting to use the process of retroduction discussed earlier to generate more effective theory of foreign language teaching. Apparently, during the 1970's (and later) quite a bit of interest and excitement was generated about the possibility of attaining "higher" states of consciousness through a form of meditation known as Transcendental Meditation (TM). Research has been conducted on the effect of TM on learning, and in particular language learning. For one such example see Dodds (1975). Collier's argument goes like this:

1) Empirical studies of TM meditators reveal that these people experience states of consciousness with characteristics that on the face of it would enhance teaching and learning interaction.
2) If such a state of consciousness exists elsewhere in nature besides in humans "this fact would add interest and impetus to the search for further scientific data about it, and broader interest on the part of teachers and students to experience and use such a state" (p. 145).
3) Several parallels between quantum theoretic phenomena and such states of consciousness exist. (I have summarized Collier's fascinating parallels in the immediately following paragraph.)
4) We should use these parallels to guide research (including research in foreign language teaching) until they either break down or yield fruitful new directions.

Collier draws several analogies between states of consciousness attained during TM and recognized quantum theoretic phenomena such as laser light and super conducting fluids. 1) Language used by psychologists to describe TM—coherent, stable, unified, pure and non-chaotic—is similar to that used to describe laser light. Some studies of brain waves of meditators show a relatively correlated firing of brain cells. 2) The use of mantras to initiate and deepen meditiative trance bears an analogy to the process of simulated emission in laser light—the analogy is between bathing the nervous system with (sound) vibrations conducive to coherence and bathing atoms with a particular frequency of light in order to stimulate further photon emission in that frequency range. 3) The "Sanscrit science of sound, which stores higher dimensional information (i.e. form) in a lower dimensional medium (i.e. sound) and uses the state of pure consciousness to release that higher dimensional data [is analogous to using coherent laser light to generate a hologram] which is a lower dimensional film recording of a higher dimensional field" (p. 149). 4) Meditators use words like timeless, boundless, changeless, and speak of a level of pure consciousness from which energy, intelligence and creativity stem. Collier notes that Feynmann graphs of electron scattering show particles moving through space backwards in time. It is only in our localized position as observer that our concepts of space, time, change, present and future can be applied. 5) Meditators describe the coexistence of both states of pure awareness and normal conscious activity. This is analogous to the coexistence of super cooled helium with "normal" helium at a certain transitional temperature. 6) Other examples of quantum coherence on a macro level are super conducting metals and super conductive magnetism. Important for this paper are the ideas that experienced transcendental meditators experience lowered anxiety and inhibitions, lowered "resistance" to the demands of the learning system, and even a boundlessness and nonlocalization in a world of boundaries.

Collier acknowledges a debt to Lawrence Domash and attributes two references to him. I have not been able to verify the existence of these references, but apparently a manuscript once existed.

A reevaluation of educational research methodology

Schuck and Haggerson (1991) propose that "a misunderstanding of the nature of modern science can contribute significantly to our confusion about the nature of education" (p. 57). They trace the

development of human scientific thinking, then, as a way of understanding modern science. Natural scientists have accepted a quantum mechanical view of the world that holds that "the world is a mass of uncertainties piling up into liklihoods." Such a view is at odds with the views of most social scientists, who are still in the grips of a model of science as certainty which evolved in the Age of Reason.

The authors are critical of educational researchers who promise certainty—"who developed a Neo-Priesthood complete with jargon, rituals, and mysterious protocols"—and educational practitioners who seek such certainty. Ignoring the limitations of empirical statistical methods is particularly being singled out here, e.g. ignoring the fact that statistical inference is, after all, only a series of probability statements or overlooking the fact of Type II errors. The teachings of Madeline Hunter are singled out as a particular example of a false promise of certainty in practice.

The authors are calling for the development of new paradigms of educational research to replace the old ones, which made false promises of certainty. They are calling for, in short (and not all that clearly), a quantum theoretic reevaluation of educational research. Consider these statements:

> If the discipline of education is to progress, we must absorb intellectually the difficult and bewildering principles that quantum theory has shown us reside in the heart of nature.
>
> We must live with our personal and professional quantum mechanics that tell us much about our world, with the caveat that we should not be too sure.

For Schuck and Haggerson, then, such a reevaluation of educational research results in a transformation of the processes by which we are accustomed to think and function. They define three modes of inquiry or research paradigms: rational, mythological, and evolutionary. They explicate these modes of inquiry in two ways, first, using the stream analogy of Jantsch (1975) and second, as a table that indicates five characteristics of each of these three modes of inquiry: problem source, role of researcher, method of inquiry, subject, and ends. Below is a portion of a table they include in their paper:

Modes of Inquiry			
Type of Inquiry	Rational	Mythological	Evolutionary
End of Inquiry	generalizations; predictions; theoretical validation	hypotheses; decisions; actions; policies; theories	change; transformation; health; high-level well-being
Method of Inquiry	objective; historical; descriptive; experimental; analytic; evaluative; deductive	phenomenological; naturalistic; ethnographic; case study; ideographic; inductive-deductive	Time, Space and Knowledge exercises; therapy meditation; self-history; journal writing; hermeneutics

Using the stream metaphor, they note that in the rational mode, the inquirer sits on the stream bank and measures its characteristics, all the while presuming not to affect the stream in any way. The mythological mode of inquiry, the researcher is in a boat in the middle of the stream. The questions asked always reflect the relationship of the boat to the stream. In the evolutionary mode of inquiry, the researcher has a sense of identity with the stream. Some examples of these differing modes of inquiry are given.

These authors are long on metaphor and short on details, but their musings are based on definite trends in educational research. Here is a succinct statement of what they have to say about the ends of the three methods of inquiry:

> In contrast to the rational mode where the ends or outcomes of inquiry are generalizations or predictions, or to the mythological mode where the sought-for outcomes are policies, decisions or hypotheses, the desired outcome in the evolutionary mode is nothing less than transformation. We move to what seems like a different level of health, or understanding, or knowledge, or reality. (p. 62)

A model for school adaptability

Garmston and Wellman (1995) draw on evolutionary biology, chaos theory and quantum theory to propose that high schools be adaptive, rather than adapted. From an evolutionary biological perspective, adaptive individuals are more flexible generalists, while adapted individuals require a specific environmental niche. Quantum theory has brought about a change in our picture of the world. Instead of viewing the world as a gigantic machine with interacting, solid parts, the "universe [is] composed of webs of relationships created from and connected by energy in motion." They note some of the standard facts about subatomic particles: that they can appear as waves of probability, that we cannot study the wave and particle characteristics of them with the same observation, that observing them results in influencing them.

The authors comment briefly on parallels between the paradoxes of the subatomic world and human social systems, including schools. These comments lead them to agree with Wheatley (1992) that "in quantum schools, leaders pay attention to the flow and interchange of energy. Energy, not things, becomes the avenue to attainment." They also note the work of Costa and Garmston (1994), who report evidence of five human energy fields, or states of mind: efficacy, flexibility, craftsmanship, consciousness, and interdependence.

> These five states of mind are the catalysts, gyroscopes, and energy sources fueling self-renewal and high performance. For an individual, they represent the continuing tensions and resources for acting holonomously—that is independently and interdependently. For an organization , they form an invisible energy field in which all parties are affected as surely as a strong magnetic field affects a compass.

While it is beyond the scope of this paper to present a summary of Garmston and Wellman's theory, they do give rather precise characterizations of each of these five states of mind. For example, they tie the concept of efficacy to the work of others in the field. Efficacious people have an unassailable belief in the liklihood of their own success (Garfield,1986) and work harder, persevere through failures, and experience less stress (LaBorde, 1984).

One of the five states of mind generative of organizational adaptability they term consciousness. They cite Csikszentmihalyi (1993) for their definition: "Consciousness means one is aware that certain events are happening (thoughts, feelings, intentions, behaviors), and that one can direct their course." However, my reading of their article suggests that they are not aware that quantum theory itself has been proposed as a basis for a theory of consciousness.

The authors also comment on the relationship between their relatively precisely defined five states of mind in individuals and the energy fields that these set up in organizations such as schools. They note an application of the "butterfly principle:"

> Schools, like weather systems, are nonlinear systems that change radically with the folding and refolding of feedback into themselves. And, since tiny inputs reverberate into big changes, we can work for transformational results by deliberately influencing the right inputs.

And, the "right inputs" for the authors are clearly reinforcing the five states of mind they identify, which:

> can be learned, mediated, and brought to bear fruit in an organization dedicated to tending them and harvesting them as resources. They are the self-referencing resources of high-performing individuals, and in an organization they create the interacting energy fields in which all parties are collectively affected.

They note an example of the influence of efficacy and interdependence on curriculum implementation in the work of Poole and O'Keafor (1989).

Again, it is beyond the scope of this paper to give an accurate summary of the extensive theory proposed by Garmston and Wellman. 1) They give a specification of what it is for organizations and schools to be adaptive and create adaptivity, 2) they offer maps to understanding and developing organizational and professional capacities for adaptivity, and 3) they define facilitator, presenter, coach and consultant as shared leadership roles.

As intriguing as is these authors' theory, one could well ask what is the advantage of viewing an educational organization as being permeated by energy fields. At least in this treatment, five characteristics of individuals in adaptive schools have been given rather specific empirical footing, but the relationship of these characteristics to the energy fields they allegedly generate is not clearly specified at all. Instead we are given vague analogies between schools and weather systems, on the one hand, and between schools and microphone feedback on the other. Is there some adaptive advantage to individuals' using such a metaphor? Could theories of organizational communication channels or instructional training models provide a better basis for studying the dissemination of adaptive characteristics of individuals in organizations? These questions remain unanswered.

Guidelines and Questions

Each one of the five research studies abstracted above have plowed fertile ground and have left us with unanswered research questions. I note some of these questions now. From Center's inquiry we wonder these things:

- How may we describe the contents of a behavior-disordered child's consciousness?
- Which of these contents have a causal relationship to the child's behavior?
- How will we determine what non-conscious mental factors bear a causal relationship to the child's behavior?
- How will we determine what environmental factors bear a causal relationship to the child's behavior?
- How may we, through language or meaningful guidance, alter a child's consciousness so that it can be truly said that some aspects of the child's consciousness are having an positive impact on his or her behavior?

From Martin-Smith's inquiry we wonder these things:

- How may we describe possible drama roles that a child may adopt?
- How may we describe a child's self-image?
- How may we describe the image that results from a child's adopting a drama role?
- How may we describe the change in a child's self-image that results from a child's adopting a drama role?
- In particular, how may we describe any archetypical images that emerge during drama work with children?
- What is the role of such archetypical images in the transformation of the child's self-image?

From Collier's inquiry we wonder these things:

- What is the relationship, if any, between meditation-induced states of consciousness and properties of macro level quantum theoretic phenomena?
- What is the research basis for altered states of consciousness, particularly those induced by meditation?
- Which altered states of consciousness are beneficial for foreign language learning?
- What are the conditions under which these altered states of consciousness may be maintained for effective foreign language learning?

Schuck and Haggerson give us cause to reflect on these questions:

- Though rational, mythological and evolutionary modes of inquiry seem to have discrete ends as described in the table on p. 13, might it be a mistake to suggest that there can be no duplication of some methods of inquiry across modes? For example, might not deduction play a role in all three modes?
- We long for a more careful specification of these three modes, particularly with regard to methodology.

We ask these questions about Garmston and Wellman's inquiry:

- What kinds of energy fields are these? Are they like electromagnetic fields? Gravitational fields? What unique characteristics do these fields have?
- Might we study the "spread" of the five empirically based characteristics of adaptive individuals using a communication model or a training model?
- What would a theory of energy fields add to such characterizations?

Finally—and beyond receiving clarifying answers to the many questions raised above—one might wonder what has this review of the significance of quantum theoretic models of consciousness for educational research accomplished with regard to a clearer conception of consciousness in education. One clear implication seems to me to be that consciousness may be less like a rock than it is like a macro level quantum effect. In the unity of the rock, we have atoms held together in molecular matrices. In the unity of the hologram, we have subatomic particles held together by quantum coherence phenomena. This may explain why so many of the characteristics of quantum coherence phenomena prove to be fertile metaphors for aspects of consciousness in at least three of the studies reviewed above.

But beyond this, I am struck by a prominent deficiency in current quantum theoretic models of consciousness. They do not offer a clear explication of the relationship between language, meaning and alleged Bose-Einstein condensates. We really don't understand from these models the relationship between our percepts and our concepts. Language and meaning are at the heart of education, so we need better development of our quantum theoretic models in these areas before our retroduced educational theory will bear significant fruit. Or perhaps we can work backward from educational phenomena to an explication of the devising model. Noting a deficiency, of course, does not amount to a devastating criticism. I suspect that there is a fertile ground for inquiry in examining the relationship between the perceptual control theory noted by Center and the holographic models of perception that he earlier notes.

Using phenomenological reflection on my own consciousness, the meaning component seems distinct from the holographic component. Indeed, there appear to be two levels of meaning, the meaning of perceptual objects for their unfolding and the meaning of descriptions of perceptual objects. While they may be located in the perceptual hologram, neither of these two meaning levels have their structure or function exhausted by such an identification. The meaning of language may be a distinct quantum phenomenon from that of perception and perhaps only tangentially related to the model of a hologram. The experience of the meaning of a word appears to be instantaneous. Others have suggested (e.g. Wolf, 1981, 1984) that making decisions is a quantum phenomenon, whereby a field of possibilities suddenly becomes a probability through a series of actions.

In conclusion then, I have met my stated objective to abstract and discuss the approaches of five educational theorists who have used quantum theory as a model for educational phenomena, to set forth and use metatheoretical criteria to evaluate the work of these theorists, and to state guidelines for further work in this domain. Each of the works by Center (1997), Martin-Smith (1995), Collier (1974), Garmston and Wellman (1995) and Shuck and Haggarson (1991), using a process of retroduction noted by Pierce and explicated by Maccia and Andris, have produced educational theory using quantum theory as a devising model. These educational theories remain to be validated by induction. Two special methodological approaches have been noted: the case study approach holds promise for understanding individual human behavior, and the within subjects approach developed by Howard holds promise for the study of self-determined behavior. In addition, special philosophical and humanistic methods may be required to explicate the

linguistic and meaning components implicit in educational phenomena. A range of clarifying questions for extending each of five inquiries has been proposed. And finally, a direction for clarifying quantum theory as a devising model for educational theory has been proposed, namely, clarifying the relationship between meaning, language and quantum theoretic phenomena, particularly holographic models of consciousness. I believe that there is an extensive and exciting field of inquiry here awaiting our questing.

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